

1. DESCRIPTION

PC-SPRINT is a low cost (\$25 - \$50) speed up for the IBM PC/XT that you can build yourself. It can achieve processor performance increases of up to 2 times normal, does not use an expansion slot, doesn't make any permanent changes to the computer and maintains software compatibility without restrictions. As an additional bonus, it adds a true hardware reset - no more "keyboard lockup".

PC-SPRINT is also an experiment to determine if hardware designs can be placed in the public domain, as a type of "freeware", and be distributed by electronic means only. This package contains all the information needed to build PC-SPRINT, including instructions, schematics, part placement diagrams, and precision artwork from which a printed circuit board can be made. Although this sounds rather formidable, PC-SPRINT should be within the capabilities of the average electronic hobbyist. I would appreciate your comments on this project, and the experiment in general. You are welcome to send me a note at the following address.

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2. CAVEATS

As an old "hardware hacker", I consider this project simple and straight forward - but that's easy for me to say. If you feel nauseous at the mere thought of removing your PC's cover, pass this up or get help. Maybe your user's group could arrange to have some made at reasonable cost.

The claims made here are real - this package was done on a PC running an 8 megahertz (mhz) V20 processor at 7.37 mhz. The actual performance increase provided by PC-SPRINT depends on what your particular computer can handle, and on choice of processor. In my case, the faster clock provides a factor of 1.55X (7.37/4.77); the V20 is variously rated at 1.1 to 1.4X over an 8088 at the same clock, giving an overall factor somewhere between 1.7 and 2.1X.

Unfortunately, a 7.37 mhz clock, with no "wait states", pushes the PC's design to its limit. Your particular setup may not be capable of full speed, but with a simple component change to PC-SPRINT (explained later), you can find your machines maximum. If your PC has a 5 mhz 8087 (number cruncher chip), it must also be replaced along with your original 8088.

If you do decide to give this a try, check one very important detail before committing any time or money - PC-SPRINT depends on replacing the PC's 8284A clock IC with a circuit board - on most PC's and XT's I've seen, this chip is socketed and easily removeable. However, this is not true for all machines. Using the directions given in the installation section, open up your PC, locate its 8284A, and make sure it is in a socket. If not, you must unsolder it from the motherboard and put a socket in its place. This isn't too difficult, but may not worth the effort.

3. CONSTRUCTION

The parts list shows all components needed to build PC-SPRINT; Radio Shack catalog numbers are given for some parts as a reference. Most items should be available by mail order - check the ads in BYTE or RADIO ELECTRONICS. As resistor/capacitor values are not critical, substitutions can be made freely - but try to keep within +/- 10%. Make sure that the processor you order (8088 or V20) is rated at 8 mhz. Its also a good idea to get extra crystals (18.342 mhz or 20 mhz) just in case your PC won't run at full speed. The external switches can be mounted in any convenient manner, but the plastic box specified is handy and cheap. If you can't locate the terminal strip for the cable, it can be directly soldered in the board, but this will make routing the cable more difficult. The square pads on the top of the 2x artwork mark pin 1 of IC's, + side of polarized capacitors, and cathode side of diodes.

The key to building PC-SPRINT is making a printed circuit board from the provided artwork. This mainly entails duplicating (at 1X size) the circuit pattern on a blank copper board, then "etching" away the unused copper not covered by the pattern. Several manual or photographic techniques are possible, using materials made for the purpose. Check with local electronic parts distributors for products or complete kits made by Radio Shack, DATAK, Kepro or G-C Electronics.

I have included 1X and 2X artwork for both sides of the circuit board. Because of printer resolution, the 1X version is really only useful as a placement/routing guide if you manually copy the pattern; use the 2X for details. You do not have to make the board double-sided - although that makes a neater job of it - just do the bottom and duplicate the top connections with 30 gauge wire. The 2X artwork is very accurate and "camera ready". For both 1X and 2X versions, the "top" or component side, is shown as you would actually view the board from the top. The bottom (solder side) is shown as you would see it if you could look "through" the board from the top; thus it is a "mirror" image and must be flipped over to see how it would be if you saw it from the bottom. This may be confusing, but is standard practice, and really presents no problem for photographic techniques as the negative can be turned over for actual transfer to the board.

Here is a list of some of the ways the board can be made. If you use the 2X artwork directly, check for horizontal breaks on the printout; I've noticed that some printers "drag" a print pin occasionally when doing graphics - the effect should be obvious if it happens.

- 1) The easiest method is to draw the pattern directly on the bare board, using a special etch resist pen (available at Radio Shack). This will work, but will likely give poor results.

- 2) Standard pressure sensitive patterns can be purchased (also at RS) and used to duplicate the layout in a "cut and paste" manner on the copper blank.

- 3) Using pressure sensitive patterns, copy the artwork on clear plastic sheets, then contact print a negative using printed circuit reversing film. The negative can then be used to contact print the layout on special photo-sensitive copper boards.

- 4) The best technique is to have the supplied 2X artwork photographically reduced to an actual size negative, then contact print on photo-sensitive boards. A good photo shop can make the negative.

5) A variation of the last technique is to reduce the 2X artwork on an ordinary reducing XEROX machine. A double reduction of 71% will be close enough ($0.71 \times 0.71 = 0.5041$) if the machine can't do half-size. The last reduction can be on "transparency" film, and then used to contact print a negative. Ordinary copier paper can be used, but requires some further steps; you can make a "decal" using "lift-it" film (available from electronic suppliers) or spray several coats of clear acrylic on both sides of the paper to make it translucent (this does work - but exposure time more than doubles). In either case, check the final copy for flaws and "touch-up" where necessary with a black fine tip marker.

After the board is etched, cleaned and trimmed to size, check it for shorts and breaks. Drill all holes with a #64 wire gauge drill bit (use a small hand drill or "pin vise"). Slightly enlarge the holes for the cable terminal strip.

Next, solder in the jumpers if you're using a single sided board, or, if double sided, solder pieces of bare wire on both top and bottom to make the feed through connections (see "feedthru sketch"). Trim off excess wire.

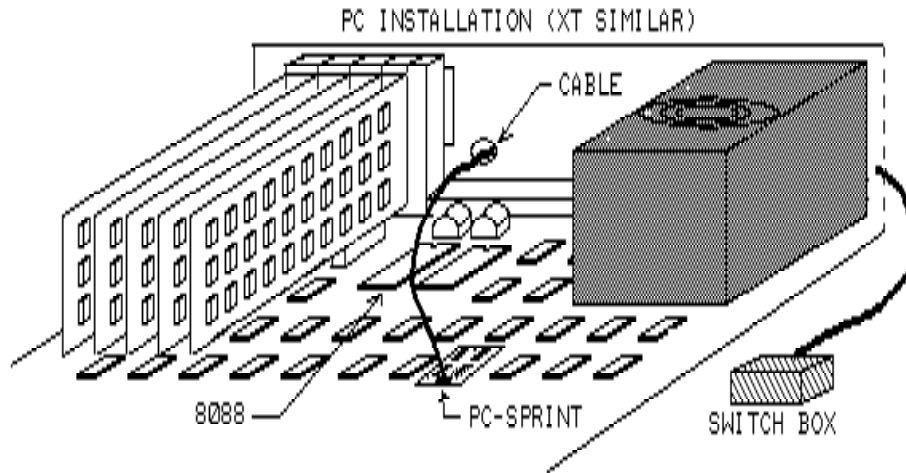
Using the "partlist" drawing, place the diodes, resistors and capacitors in the proper holes, forming the leads as you go, and solder in place. Then place a small piece of cellophane tape on the top of the board where the crystal will go to prevent the crystal's case from shorting. Install the crystal vertically and solder in place. Trim off excess wire.

Then install the two 18-pin "solder tail" IC sockets at U2 and U3, and the 18-pin wire wrap socket at U1. Solder all socket connections. Try not to get excess solder on the wire wrap pins, and make sure they are properly connected. Finally, insert the terminal strip and solder in place. Clean off solder flux with rubbing alcohol and a cotton swab. Install the new 8284A in the socket at U3 to complete construction of the board.

To make the switch box, remove the aluminum cover and drill two holes (usually 1/4") for the switches; notch the plastic box for the cable, and install the switches. Next cut the cable to length (3 to 4 feet), nick the insulation on both ends, and split the individual wires apart for a length of 1 to 2 inches. Strip off 1/4" of insulation from each wire end and solder either end of the cable to the switches (use the schematic diagram for the proper connections). It doesn't matter which wires are initially connected to which switch, but write it down since you must know when you insert the cable on the PC-SPRINT board. Make sure you have used the "normally-open" contacts on the push button switch - otherwise, the computer will be held "reset". Replace the switch box cover, placing the cable in the notch so that it doesn't get damaged.

4. INSTALLATION

If you've gotten this far, the rest is easy. The general idea here is to remove and replace the 8088, remove the original 8284A and put it on PC-SPRINT, route the switch cable and install PC-SPRINT in place of the 8284A. As you carry out the following directions, try not to directly touch any chip legs, as static electricity could damage them. Discharge yourself by occasionally touching some large piece of metal, like the computers case.



First, and most important, unplug the computers power cord from the outlet to prevent any possibility of shock. While you're at it, disconnect all external cables (crt, keyboard, printers, modem, etc.) to protect them from you and you from their power systems.

Using the manufacturers directions, remove the computers case to gain access to the motherboard.

Locate the 8088 processor (40 pin chip), note the direction of the notched end, and very carefully remove it. This may be done by alternately prying up on the ends of the chip a little at a time until it eases out (use a small screw driver or bent piece of metal). Another method is to fashion a 3/8 inch wide, 12 inch long strip of thin, flexible plastic, slide it beneath the chip from either open end, fold upward, and pull on both ends with a rocking motion until the chip pops out (be careful as the chip may fly out with considerable force - keep your face well to the side). Put the old processor into whatever protective packing the new one came in and save it. Insert the new processor into the vacant socket, making sure that the notched end is in the same direction as the original. You may have to bend the chip legs to fit by pushing the chip sideways against a flat surface so that all pins on a side deflect together. Try not to exert excessive downward force on the motherboard as you push the new chip into the socket.

Find the 8284A (18 pin chip - note notch direction) and remove it in a similar manner. On PC's, it's located close to the internal disk drives, around the configuration switch. For XT's, it's towards the back of the case next to the expansion slots. In either case look for the metal crystal can - the 8284A will be very close by. Insert the removed 8284A into the socket at position U2 on the PC-SPRINT board, as shown by the parts diagram.

At this time, route the flat cable from the switches into the computer. Use any convenient path, but make sure that more than enough cable is inside the computer to reach the original 8284A socket (and then some). If you choose to run the cable over the back edge of the chassis, rather than using a back plate hole, protect both sides with electrical tape or use paper binder clips, on both sides, to force the cover to "ride" over the cable. Now open the terminal strip (on the bottom edge of the PC-SPRINT board) by pulling up on its plastic body, insert the pre-stripped ends of the cable into the holes (wire 1 to pin 1, etc), and close by pushing down on the body. Make sure the cable is seated firmly.

Carefully align the underside pins from the PC-SPRINT board with the 8284A socket on the motherboard, checking that the chip notches are in the original direction, and push down firmly until you feel it "grab" in the socket. Check that all pins are seated in the socket (a small mirror might be handy) and that the PC-SPRINT board is level with the motherboard. The cable should be routed upward and gradually fold back over the PC-SPRINT board towards the back of the computer.

You're now done with the installation. Replace the cover, re-attach all cables, place the switch box in a convenient location, plug in the power cord, set the speed switch to normal, hold your breath and power up.

If everything worked ok, the computer should "boot" normally. At DOS prompt, push the reset button - the machine should boot the same as "power-up". Now run some of your programs (use backup copies - just in case) to verify that everything else works. Flip the speed switch to high and re-execute the same programs. They should run noticeably faster. Since PC-SPRINT speeds up only the processor, programs that do a lot of I/O work (disk, screen, etc.) won't show much improvement. Processor intensive operations, like spreadsheet recalcs, graphics, in-memory database searches, etc., should be much more responsive.

What if the computer doesn't work now ?.

First, recheck the installation looking for obvious problems such as:

- 1) cables or power cord not reattached
- 2) improper PC-SPRINT board installation (misaligned, not fully in socket, wrong socket, etc)
- 3) processor misaligned or pins bent under the chip (very common)
- 4) switch cable damage
- 5) loose switch cable connections
- 6) reset switch wired to normally closed contacts instead of normally open

If nothing is found at this stage, remove and recheck the PC-SPRINT board for the following:

- 1) wrong parts or parts not in the correct holes
- 2) chips, tantalum capacitors or diodes installed backwards
- 3) crystal can shorting foil traces
- 4) bad solder joints
- 5) open or shorted foil traces
- 6) missing feedthrough wires (double sided) or jumpers (single sided)

Hopefully, you've now found something, fixed it, and are happily running at high speed. If not, the problem may be more subtle, but still not too difficult to find. You could have a bad processor or other component, but most likely, something just can't handle the speed increase. Except for the processor, the basic design of the PC should be capable of operating at 7.37 mhz, but some adapter and ram expansion boards may not - particularly if somebody cut corners and used 200 ns rams instead of 150 ns types. The thing to do now is to back off the speed a bit. Remove the 22.11 mhz crystal from the PC-SPRINT board and replace it with a 20 mhz or even an 18.43 mhz version - still a substantial speed up.

5. OPERATION

I have included two programs with this package. The first - NOPRTYCK.COM - is a public domain program which stops all memory parity checks (my regards to the unknown author). Some expansion boards will work ok at high speed - except that their parity check circuits are too slow. If you can't boot up at high speed without the infamous "PARITY CHECK x" message, restart at normal speed and execute this program (once between resets) BEFORE switching to high.

The other, WARMBOOT.COM, is a simple program to set the flag which causes the bios to skip memory tests on reset. If you include it in your AUTOEXEC.BAT file, each time you restart with PC-SPRINT's reset button, the computer will come up very quickly (the same as a ctrl-alt-del).

Operation of PC-SPRINT's switches is obvious. The toggle switch determines the speed (high or normal - which way depends on how you wired it) and the reset push button causes a hardware restart without powering down. In use, the speed switch can be changed anytime - even while a program is running - without problem, but try to do it at DOS prompt level. Keep the switch box out of the way so that you don't inadvertantly hit the reset button. When you really want to restart, tap the button firmly but quickly, otherwise the warmboot flag will be lost.

6. THEORY

The basic idea behind PC-SPRINT is simple - run the processor at a higher clock rate and processing speed goes up proportionately. On the IBM AT this can be done merely by replacing the processors' crystal - for the PC & XT things aren't quite so easy for the following reasons:

- 1) The 8088 processor supplied is specified to run at only 5 mhz.
- 2) Operation of the timer circuits (interrupt, sound, etc.) ultimately depends on the original frequency which must then remain constant to maintain software compatibility.
- 3) A few common expansion boards (such as the color graphics adapter) require the original clock to operate correctly.
- 4) Some programs use "software timing loops", and are therefore processor speed dependent.

PC-SPRINT attempts to solve these problems by running two crystals simultaneously (the original and a higher frequency). This allows changing only the processors clock, while keeping all other frequencies constant. Obviously, the processor must be replaced with a higher speed version.

To gain easy access to the needed connections, PC-SPRINT replaces the 8284A clock generator on the PC's motherboard, but reconnects some of the 8284A's signals through itself, including the oscillator signal, thus keeping that constant.

By adding another 8284A and crystal, a new frequency source is generated which can then be used to drive the unused external frequency input of the original 8284A. The original 8284A will then choose which source to operate from based on the logic level at its F/-C input (high = external, low = crystal) and generate the processors clock accordingly.

The 8284A contains additional circuits to generate processor reset and to select and synchronize the processors "ready" line (used to cause the processor to wait for slow devices). By cross wiring the oscillator outputs of each 8284A to the others external frequency input and using the ready select circuits of the new 8284A, the PERIPHERAL CLOCK output (which feeds the timer circuits on the motherboard) is kept constant at its normal frequency as its source is selected by the same logic signal used for switching the processors clock.

As mentioned previously, the 8284A also generates the processors reset. By "diode or-ing" the motherboard reset line with the debounced output of a momentary switch, a true (as opposed to the software generated "ctrl-alt-del") reset is provided. This "diode or" violates normal logic thresholds, but works in this case because the reset input of the 8284A is a "Schmitt trigger" type with higher than normal levels (when the hysteresis is added).

The unused reset circuit of the added 8284A is combined with the output of a toggle switch to generate the logic level which switches the processors clock, giving manual control of speed. Both the reset switch and the speed switch use a pull up resistor to supply logic "high", and a capacitor to filter switch "bounce". These slow transitions are "squared off" by the Schmitt trigger inputs.

7. COMMENTS

I hope you find PC-SPRINT of some value. I've tried to give as much information as I can without making it my life's career. If interest in this experiment is sufficient, I may add some enhancements to PC-SPRINT in the future, as well as releasing other projects.

GOOD LUCK !

8. LICENSE

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